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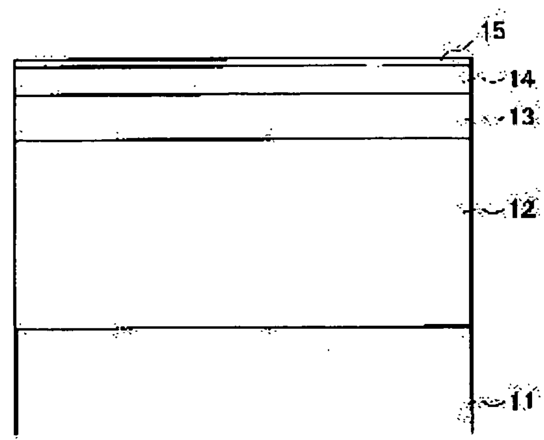
(54) PERPENDICULAR MAGNETIC RECORDING MEDIUM AND MAGNETIC STORAGE DEVICE

(57)Abstract:
PROBLEM TO BE SOLVED: To provide a perpendicular magnetic recording medium and a magnetic storage device capable of reducing medium noise caused by a soft magnetic base layer without reducing recording sensitivity.
SOLUTION: In the perpendicular magnetic recording medium constructed by successively laminating an intermediate layer and a perpendicularly magnetized layer on the soft magnetic base layer, the film thickness of the intermediate layer is set to be thicker than that of the perpendicularly magnetized layer.

本発明になる垂直磁気記録媒体の第１実施例の要部を示す断面図



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CLAIMS

[Claim(s)]

[Claim 1] It is the vertical-magnetic-recording medium which is a vertical-magnetic-recording medium of the structure where the laminating of an interlayer and the perpendicular magnetization layer was carried out one by one on the soft-magnetism ground layer, and is characterized by setting up this interlayer's thickness more than the thickness of this perpendicular magnetization layer.

[Claim 2] The aforementioned soft-magnetism ground layer consists of material chosen from the group which consists of NiFe, FeTaC, CoZrNb, FeAlO, FeN, and FeSiAl. the aforementioned interlayer It consists of material chosen from aluminum 2O3 and the group which consists of SiO2, Cr, and Ti. the aforementioned perpendicular magnetization layer The vertical-magnetic-recording medium according to claim 1 characterized by the bird clapper from the selection ****** material from the group of an alloy which has a perpendicular magnetic anisotropy containing CoCr, CoCrPtTa, CoCrNbPt, Co/Pd, TbFeCo, FePt, and gammaFe 2O3.

[Claim 3] Magnetic storage characterized by having a vertical-magnetic-recording medium according to claim 1 or 2 and a shielded type GMR head.

[Claim 4] The aforementioned interlayer's thickness is magnetic storage according to claim 3 characterized by being larger than the magnetic spacing from this GMR head surfacing side to the perpendicular magnetization layer front face of the aforementioned vertical-magnetic-recording medium.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[The technical field to which invention belongs] Especially this invention relates to the magnetic storage using the vertical-magnetic-recording medium and such a vertical-magnetic-recording medium which adopt vertical magnetic recording about a magnetic-recording medium and magnetic storage.
[0002] At vertical magnetic recording, magnetic recording is performed by being magnetized in the direction perpendicular to the magnetic-film side of a vertical-magnetic-recording medium. For this reason, the vertical-magnetic-recording medium fits high-density record.
[0003]
[Description of the Prior Art] Drawing 1 is the cross section showing the important section of an example of the conventional vertical-magnetic-recording medium. A vertical-magnetic-recording medium consists of a substrate 1, the soft-magnetism ground layer 2, an interlayer 3, a perpendicular magnetization layer 4, and a protective layer 5. A substrate 1 consists of an aluminum alloy etc. The soft-magnetism ground layer 2 consists of NiFe etc., and has 0.2-1-micrometer thickness. An interlayer 3 consists of Cr, Ti, etc. and has thickness 5nm or less. The perpendicular magnetization layer 4 consists of CoCr etc., and has 20-50nm thickness. A protective layer 5 consists of DLC etc. and has 5-10nm thickness.
[0004] The soft-magnetism ground layer 2 is formed for improvement in record sensitivity and reproduction sensitivity. Since the vertical component of a recording head magnetic field increases sharply, the vertical-magnetic-recording medium of the high coercive force Hc (high anisotropy magnetization Hk) is realizable with existence of this soft-magnetism ground layer 2. It is indispensable to obtain the high coercive force Hc (high anisotropy magnetization Hk) in order to realize thermal stability of a vertical-magnetic-recording medium.
[0005] An interlayer 3 is formed so that it may have the crystallinity which was excellent from the initial stage of growth, without influencing the good adhesion of the perpendicular magnetization layer 4, and the perpendicular magnetization layer 4 of the crystal-lattice structure of the soft-magnetism ground layer 2. Since it aims at carrying out induction of the epitaxial growth of the perpendicular magnetization layer 4, this interlayer's 3 thickness is set up small. Moreover, if an interlayer's 3 thickness is set up greatly, causing aggravation of the steepness of a recording head magnetic field distribution is known conventionally. In addition, the perpendicular magnetization layer 4 is formed with the material which is not theoretically influenced of crystalline by the soft-magnetism ground layer 2, and the vertical-magnetic-recording medium which does not form an interlayer 3 is also proposed.
[0006]
[Problem(s) to be Solved by the Invention] However, while the improvement in the record sensitivity by the soft-magnetism ground layer 2 had a very big effect, it had the problem that a medium noise increased sharply, by existence of the soft-magnetism ground layer 2.
[0007] Then, this invention aims at offering the vertical-magnetic-recording medium and magnetic storage which can reduce the medium noise which originates in a soft-magnetism ground layer, without reducing record sensitivity.
[0008]
[Means for Solving the Problem] The above-mentioned technical problem is the vertical-magnetic-recording medium of the structure where the laminating of an interlayer and the perpendicular magnetization layer was carried out one by one on the soft-magnetism ground layer, and the vertical-magnetic-recording medium characterized by being set up more than the thickness of this perpendicular magnetization layer can attain this interlayer's thickness.
[0009] The thickness of the perpendicular magnetization layer of the aforementioned vertical-magnetic-recording medium may be 10-50nm, and the aforementioned interlayer's thickness may be 10-100nm.
[0010] The thickness of the soft-magnetism ground layer of the aforementioned vertical-magnetic-recording medium may be 0.1-1 micrometer.
[0011] Moreover, the soft-magnetism ground layer of the aforementioned vertical-magnetic-recording medium It consists of material chosen from the group which consists of NiFe, FeTaC, CoZrNb, FeAlO, FeN, and FeSiAl. the aforementioned interlayer It consists of material chosen from aluminum 2O3 and the group which consists of SiO2, Cr, and Ti. the aforementioned perpendicular magnetization layer It is good also as composition which consists of the group of an alloy which has a perpendicular magnetic anisotropy containing CoCr, CoCrPtTa, CoCrNbPt, Co/Pd, TbFeCo, FePt, and gammaFe 2O3 to selection ****** material.

[0012] The magnetic storage characterized by having one of the above-mentioned vertical-magnetic-recording media and shielded type GMR heads can also attain the above-mentioned technical problem.
[0013] The aforementioned interlayer's thickness may constitute magnetic storage so that more greatly than the magnetic spacing from this GMR head surfacing side to the perpendicular magnetization layer front face of the aforementioned vertical-magnetic-recording medium.
[0014] Therefore, according to this invention, the vertical-magnetic-recording medium and magnetic storage which can reduce a medium noise can be realized, without reducing record sensitivity.
[0015]
[Embodiments of the Invention] Each example of the vertical-magnetic-recording medium which becomes this invention, and magnetic storage is explained with drawing 2 or subsequent ones below.
[0016]
[Example] Drawing 2 is the cross section showing the important section of the 1st example of the vertical-magnetic-recording medium which becomes this invention. The vertical-magnetic-recording medium shown in drawing 2 consists of a substrate 11, the soft-magnetism ground layer 12, an interlayer 13, a perpendicular magnetization layer 14, and a protective layer 15. A substrate 11 consists of glass, an aluminum alloy, etc. The soft-magnetism ground layer 12 consists of NiFe, FeTaC, CoZrNb, FeAlO, FeN, FeSiAl, etc., and has 0.1-1-micrometer thickness. An interlayer 13 consists of aluminum 2O3, SiO2, Cr, Ti, etc., and has 10-100nm thickness. The perpendicular magnetization layer 14 consists of an alloy which has the perpendicular magnetic anisotropy which made the principal component Co(es), such as CoCr, CoCrPtTa, CoCrNbPt, Co/Pd, and TbFeCo, and an alloy which has the perpendicular magnetic anisotropy of FePt and gammaFe2O3 grade, and has 10-50nm thickness. A protective layer 15 consists of DLC etc. and has 2-10nm thickness. In addition, the perpendicular magnetization layer 14 cannot be overemphasized by that you may make it various additives included for detailed-izing of the diameter of a magnetic particle, equalization, cutting of the magnetic interaction between magnetic particles, etc.
[0017] The soft-magnetism ground layer 12 is formed for improvement in record sensitivity and reproduction sensitivity. Since the vertical component of a recording head magnetic field increases sharply, the vertical-magnetic-recording medium of the high coercive force Hc (high anisotropy magnetization Hk) is realizable with existence of this soft-magnetism ground layer 12. It is indispensable to obtain the high coercive force Hc (high anisotropy magnetization Hk) in order to realize thermal stability of a vertical-magnetic-recording medium.
[0018] An interlayer 13 is formed so that it may have the crystallinity which was excellent from the initial stage of growth, without influencing the good adhesion of the perpendicular magnetization layer 14, and the perpendicular magnetization layer 14 of the crystal-lattice structure of the soft-magnetism ground layer 12. In this example, the feature is in the point that this interlayer's 13 thickness is greatly set up as compared with the former. That is, compared with the conventional vertical-magnetic-recording medium shown in drawing 1 , it is set up several times to dozens times, and this interlayer's 13 thickness is set up more greatly than the thickness of the perpendicular magnetization layer 4.
[0019] Drawing 3 is drawing showing the GMR head sensitivity distribution to the vertical-magnetic-recording medium when not forming setup 13, i.e., an interlayer, for an interlayer's 13 thickness in zero. A vertical axis shows sensitivity (Am/Wb) among this drawing, and a horizontal axis shows the position (micrometer) on the truck run direction of the vertical-magnetic-recording medium which made the zero the center of a shield gap of a shielded type GMR head. moreover, this drawing is [to a GMR head and a medium front face] magnetic -- the thickness of spacing Mag.spe.=30nm and the perpendicular magnetization layer 14 shows the sensitivity distribution of an about, when the thickness of 30nm and the soft-magnetism ground layer 12 is 500nm and shield gap length (shield interval) ShieldGL=110nm of a GMR head
[0020] The sensitivity distribution shown in drawing 3 calculates the magnetic field (A/m) of which arises inside the film of a GMR head with the magnetization moment (Wb/m2) in the arbitrary places of a vertical-magnetic-recording medium. Specifically, the beam state with 1 turn volume was virtually assumed for the coil to the GMR head, and it asked for the magnetic field distribution with the two-dimensional finite element method, and counted backward according to the reciprocity theorem. Among this drawing, O mark and - mark show the sensitivity distribution in the perpendicular magnetization layer 14 interior, and ** mark and ** mark show the sensitivity distribution in the portion near the perpendicular magnetization layer 14 near the front face of the soft-magnetism ground layer 12 (i.e., the inside of the soft-magnetism ground layer 12). Moreover, the distribution of x components whose y components, O marks, and ** marks - mark and whose ** mark are vertical components are a longitudinal component is shown, respectively. As shown in this drawing, to this vertical-magnetic-recording medium, as for a GMR head, it turns out that it has thing sensitivity to the soft-magnetism ground layer 12 80% or more as compared with the reproduction sensitivity to the perpendicular magnetization layer 14. For this reason, when it is in the soft-magnetism ground layer 12, fluctuation, i.e., the noise zone, of magnetization, it turns out that it reproduces simply.
[0021] Drawing 4 is drawing showing the GMR head sensitivity distribution to the vertical-magnetic-recording medium at the time of setting an interlayer's 13 thickness as 60nm which is twice [about] the perpendicular magnetization layer 14. A vertical axis shows sensitivity (Am/Wb) among this drawing, and a horizontal axis shows the position (micrometer) on the truck run direction of the vertical-magnetic-recording medium which made the zero the center of a shield gap of a GMR head. moreover, this drawing is [to a GMR head and a medium front face] magnetic like the case of drawing 3 -- the thickness of spacing Mag.spe.=30nm and the perpendicular magnetization layer 14 shows the sensitivity distribution of an about, when the thickness of 30nm and the soft-magnetism ground layer 12 is 500nm and shield gap length (shield interval) ShieldGL=110nm of a GMR head Furthermore, the round mark and triangle mark which are used by drawing 4 shall have the same meaning as the case of drawing 3 .

[0022] As shown in drawing 4 , it turns out that the GMR head reproduction sensitivity in the soft-magnetism ground layer 12 in this case is falling to about about 35% of the sensitivity in the perpendicular magnetization layer 14. Although the GMR head has 80% or more of sensitivity to the soft-magnetism ground layer 12 in the case of drawing 3 , in the case of drawing 4 , it turns out that it is made to below this abbreviation half. Therefore, in the case of drawing 4 , the influence of the soft-magnetism ground layer 12 exerted on a reproduction output becomes small, and a medium noise is reduced.
[0023] Thus, as for the reproduction sensitivity of a shielded type GMR head, it is distinct to fall, so that the distance from a head surfacing side keeps away. For this reason, the vertical-magnetic-recording medium of a high signal-to-noise ratio (S/N ratio) is realizable by keeping away the soft-magnetism ground layer 12 which does not want to reproduce the perpendicular magnetization layer 14 which wants to take out a regenerative signal near the head surfacing side again since it becomes a medium noise source from a head surfacing side.
[0024] by the way -- if thickness of a perpendicular magnetization layer is enlarged and distance to the soft-magnetism ground layer from a head surfacing side is made far -- recording head magnetic field inclination -- deteriorating -- record -- it is known conventionally that resolution will fall
[0025] On the other hand, this example completely differs from such conventional technology. In this example, thickness of a perpendicular magnetization layer is not necessarily enlarged, an interlayer's 13 thickness is enlarged, and distance from a head surfacing side to a soft-magnetism ground layer is made far.
[0026] Drawing 5 is drawing showing the recording head magnetic field over a vertical-magnetic-recording medium. A vertical axis shows a recording head magnetic field (kA/m) among this drawing, and a horizontal axis shows the position (micrometer) on the truck run direction of the vertical-magnetic-recording medium of a recording head. Moreover, y component and ** mark whose ** mark is a vertical component in case an interlayer's 13 thickness is zero show x components which are longitudinal components in case an interlayer's 13 thickness is zero. Furthermore, y component and O mark whose - mark is a vertical component in case an interlayer's 13 thickness is 60nm show x components which are longitudinal components in case an interlayer's 13 thickness is 60nm. this drawing is [to a head and a medium front face] magnetic like the case of drawing 3 -- the thickness of spacing Mag.spe.=30nm and the perpendicular magnetization layer 14 shows the record magnetic field of an about, when the thickness of 30nm and the soft-magnetism ground layer 12 is 500nm and mmf=0.4AT
[0027] Moreover, drawing 6 is drawing showing the flow of the line of magnetic flux at the time of the record to the vertical-magnetic-recording medium of this example acquired by the finite element method simulation. The same sign is given to the same portion as drawing 2 among this drawing, and the explanation is omitted. In drawing 6 , 21 shall show the up magnetic pole of a recording head, 22 shall show a return yoke, and gap length and the up magnetic pole length of both recording heads shall be the 0.5-micrometer ring heads for vertical recording.
[0028] As shown in drawing 5 , compared with the head magnetic field distribution in case the thickness of the interlayer 13 who shows by the trigonum mark is zero, the steepness of a head magnetic field is lost at the tracing side (left-hand side) of the up magnetic pole 21 which shows the head magnetic field distribution in this example shown by the round mark to drawing 6 . However, in the case of this example, the coercive force H of the magnetic field inclination near H=450 kA/m is about two 3.8x1012 A/m, and when an interlayer's 13 thickness is zero, even if it compares about with two about 4.5x1012 A/m, degradation of remarkable magnetic field inclination is not seen. it comes out to this extent, and if it is, it will be thought that a problem is not produced in the case of record The thickness of perpendicular magnetization layer 14 the very thing does not necessarily become large, and, as for this, only an interlayer's 13 thickness originates in a bird clapper greatly.
[0029] Moreover, in the case of this example, as compared with the case where an interlayer's 13 thickness is zero, the intensity of a magnetic field falls somewhat. However, since the record magnetic field which is about 750 kA/m can be expected when an interlayer's 13 thickness is about 60nm, when the vertical-magnetic-recording medium whose coercive force Hc is about Hc=450-500 kA/m is considered that it can perform good record and takes into consideration that the present condition is about Hc=200 kA/m, it turns out that it can respond enough also to a raise in future coercive force.
[0030] Next, the 2nd example of the vertical-magnetic-recording medium which becomes this invention is explained. Drawing 7 is the cross section showing the important section of the 2nd example of a vertical-magnetic-recording medium. The same sign is given to the same portion as drawing 2 among this drawing, and the explanation is omitted.
[0031] In this example, a substrate 11 consists of glass and the SiN layer 31 whose thickness is 5nm is formed on the substrate 11. The soft-magnetism ground layer 12 is formed on the SiN layer 31, and consists of FeSiAl whose thickness is 200nm. As for an interlayer 13, thickness consists of SiN 30nm or more. The perpendicular magnetization layer 14 consists of TbFeCo whose thickness is 30nm. On this perpendicular magnetization layer 14, the SiN layer 32 whose thickness is 5nm is formed, and the protective layer 15 which thickness becomes from C by 5nm is formed on this SiN layer 32.
[0032] The vertical-magnetic-recording medium of this example was created as follows. First, as a sputtering system, DC magnetron-sputtering equipment of the substrate revolution type which has four cathodes was used. a cathode -- the B dope Si, Fe86Si5.3aluminum8.7, and Tb18Fe70 -- it equipped with each target of Co12 and C The SiN layer 31 formed in the degree of a glass substrate 11 is formed in order to raise adhesion with the perpendicular magnetization layer 14. At the time of a spatter, N2 gas was introduced with Ar gas. The gas flow rate of Ar gas and N2 gas was set to 3:1, and spatter gas ** could be 0.3Pa. The spatter rate was made into 10 nm/min.
[0033] The saturation magnetic flux density Bs and coercive force Hc of the FeSiAl soft-magnetism ground layer 12 are Bs=1.4 Wb/m2 and Hc=165 A/m, respectively. Spatter Ar gas ** at the time of formation of this soft-magnetism ground layer 12 made 0.5Pa and the spatter rate 30 nm/min. The SiN nonmagnetic interlayer's 13 membrane formation conditions presupposed that it is the same as the membrane formation conditions of the SiN layer 31. The saturation magnetization Bs and coercive force Hc of

the Tb18Fe70Co12 perpendicular magnetization layer 14 formed as a record layer are Bs=0.19 Wb/m2 and Hc=330 kA/m, respectively. Spatter Ar gas ** at the time of formation of this perpendicular magnetization layer 14 made 1.0Pa and the spatter rate 20 nm/min. The SiN layer 32 has an oxidization protective effect, and formed membranes on the same membrane formation conditions as the SiN layer 31. The C protective layer 15 consists of amorphous carbon. The spatter was carried out having used the spatter rate as 5 nm/min having used Ar gas ** to C target as 0.3Pa at the time of formation of this protective layer 15.
[0034] Record core width of face measured record reproducing characteristics using the magnetic head 0.8 micrometers and whose reproduction shield gap length 1 micrometer and GMR reproduction core width of face are 0.14 micrometers. Moreover, the flying height from a head vertical-magnetic-recording medium set to 4800rpm the spindle rotational frequency turning around the magnetic disk which are about 15nm and a vertical-magnetic-recording medium.
[0035] Drawing 8 is drawing showing the measurement result of the record reproducing characteristics obtained by doing in this way to an interlayer's 13 thickness. A vertical axis shows carrier level (dBm) and noise level (dBm) among this drawing, and a horizontal axis shows the SiN interlayer's 13 thickness (nm). Moreover, O mark shows carrier level and - mark shows noise level. The measurement result shown in this drawing was searched for by changing the SiN interlayer's 13 thickness and measuring the signal (dBm) of 400kFCI by the spectrum analyzer. In addition, the bandwidth of a spectrum analyzer could be 30kHz.
[0036] It was checked that a minute mark is recordable by setting up an interlayer's 13 thickness more greatly than the thickness of the perpendicular magnetization layer 14 so that drawing 8 might also show.
[0037] Drawing 9 is drawing showing the result which changed an interlayer's 13 thickness and measured the signal (dBm) of 200kFCI by the spectrum analyzer like the case of drawing 8 . A vertical axis shows carrier level (dBm) and noise level (dBm) among drawing 9 , and a horizontal axis shows the SiN interlayer's 13 thickness (nm). Moreover, O mark shows carrier level and - mark shows noise level.
[0038] It was checked that noise level can be reduced without degrading a signal amplitude, i.e., carrier level, by setting up an interlayer's 13 thickness more greatly than 30nm so that drawing 9 may also show.
[0039] Next, the 3rd example of the vertical-magnetic-recording medium which becomes this invention is explained. The structure of the 3rd example of a vertical-magnetic-recording medium is the same as the case of the 2nd example of the above shown in drawing 7 .
[0040] In the 2nd example of the above, the thickness of the perpendicular magnetization layer 14 is fixed at 30nm, and is changing an interlayer's 13 thickness. On the other hand, in the 3rd example, an interlayer's 13 thickness was set constant by 80nm, and the thickness of the perpendicular magnetization layer 14 was changed.
[0041] Drawing 10 is drawing showing the measurement result of record reproducing characteristics to the thickness of the perpendicular magnetization layer 14. A vertical axis shows carrier level (dBm) and noise level (dBm) among this drawing, and a horizontal axis shows the thickness (nm) of the Tb18Fe70Co12 perpendicular magnetization layer 14. Moreover, O mark shows carrier level and - mark shows noise level. The measurement result shown in this drawing was searched for by setting up the SiN interlayer's 13 thickness uniformly with 30nm, changing the thickness of the Tb18Fe70Co12 perpendicular magnetization layer 14, and measuring the signal (dBm) of 400kFCI by the spectrum analyzer. In addition, the bandwidth of a spectrum analyzer could be 30kHz.
[0042] Making thickness of the perpendicular magnetization layer 14 small, i.e., by making small relatively thickness of the perpendicular magnetization layer 14 to an interlayer's 13 thickness, it becomes easy to record a minute mark and the signal amplitude has also checked the bird clapper greatly so that drawing 10 might also show.
[0043] Drawing 11 is drawing showing the result which changed the thickness of the perpendicular magnetization layer 14 and measured the signal (dBm) of 200kFCI by the spectrum analyzer like the case of drawing 10 . A vertical axis shows carrier level (dBm) and noise level (dBm) among drawing 11 , and a horizontal axis shows the thickness (nm) of the Tb18Fe70Co12 perpendicular magnetization layer 14. Moreover, O mark shows carrier level and - mark shows noise level.
[0044] As drawing 11 also shows, regardless of the thickness of the perpendicular magnetization layer 14, a signal amplitude is abbreviation regularity. On the other hand, it turns out that the noise level in record frequency is falling with reduction of the thickness of the perpendicular magnetization layer 14.
[0045] From the measurement result like the above, while record of a minute mark was attained by setting up the thickness of the perpendicular magnetization layer 14 smaller than an interlayer's 13 thickness, the bird clapper has been checked that noise level can be reduced.
[0046] Next, the 4th example of the vertical-magnetic-recording medium which becomes this invention is explained. The structure of the 4th example of a vertical-magnetic-recording medium is the same as the case of the 2nd example of the above shown in drawing 7 .
[0047] In this example, while setting the thickness of the perpendicular magnetization layer 14 as 20nm, an interlayer's 13 thickness was set as 60nm which is 3 times the thickness of the perpendicular magnetization layer 14, the quality of the material of the soft-magnetism ground layer 12 was changed, the signal (dBm) of 200kFCI(s) was measured by the spectrum analyzer, and the signal-to-noise ratio (SNR) was investigated. moreover, the thickness of a glass substrate 11 -- the thickness of 0.635mm and the SiN layer 31 -- the thickness of 5nm and the soft-magnetism ground layer 12 -- in the thickness of 60nm and the TbFeCo perpendicular magnetization layer 14, the thickness of 20nm and the SiN layer 32 set [the thickness of 200nm and the SiN interlayer 13] thickness of 5nm and the C protective layer 15 to 5nm like the above
[0048] The membrane formation conditions of each class except the soft-magnetism ground layer 12 of a vertical-magnetic-recording medium etc. presupposed that it is the same as the 2nd example of the above. On the other hand,

membrane formation conditions, magnetic properties, etc. were carried out as follows at the soft-magnetism ground layer 12 using the following NiFe system, FeTaC, CoZrNb, FeAlO, and five kinds of alloys that become FeN.
(1) nickel80Fe15Nb15 soft-magnetism ground layer 12: Saturation-magnetic-flux-density Bs=1.8 Wb/m2, spatter gas =Ar, gas ** =0.5Pa, a spatter rate = 30 nm/min(2) Fe80Ta9C11 soft-magnetism ground layer 12: Saturation-magnetic-flux-density Bs=1.5 Wb/m2, spatter gas =Ar, gas ** = [0.5Pa,] spatter rate =30 nm/min(3) Co86Zr5Nb9 soft-magnetism ground layer 12 : Saturation-magnetic-flux-density Bs=1.2 Wb/m2, spatter gas =Ar, gas ** =0.5Pa, and spatter rate =30 nm/min(4) Fe94(aluminum 2O3) 6 soft-magnetism ground layer 12: Saturation-magnetic-flux-density Bs=1.7 Wb/m2, spatter gas =Ar, gas ** = 0.5Pa, spatter rate =30 nm/min(5) FeN soft-magnetism ground layer 12: Saturation-magnetic-flux-density Bs=1.5 Wb/m2, spatter gas =Ar+N2, gas ** = [0.5Pa,] Spatter rate = SNR in 200kFCI(s) to each soft-magnetism ground layer 12 of 30 nm/min above-mentioned (1) - (5) was as follows. In addition, record reproducing characteristics presupposed that it is the same as the case of the 2nd example of the above.
Soft-magnetism ground layer 12 SNR (Spp/Nrms)
NiFeNb 23.8 FeTaC 24.9 CoZrNb 23.1 FeAlO 24.5 FeN It has checked that good SNR could be obtained by setting up 23.9, thus an interlayer's 13 thickness greatly relatively to the thickness of the perpendicular magnetization layer 14, without being dependent on the kind of soft-magnetism ground film 12.
[0049] Next, the 5th example of the vertical-magnetic-recording medium which becomes this invention is explained. The structure of the 5th example of a vertical-magnetic-recording medium is the same as the case of the 2nd example of the above shown in drawing 7 .
[0050] In this example, about the case where an interlayer 13 is formed by SiN, and the case where it forms by Y-SiO2 (Y:45at%) and C, the signal (dBm) of 200kFCI was measured by the spectrum analyzer, and SNR was investigated like the above. In addition, Y-SiO2 interlayer 13 formed by placing Y chip on SiO2 target and performing a RF spatter. Moreover, the C interlayer 13 formed by performing a spatter by the same method as the C layer used for lubricous. the thickness of a glass substrate 11 -- the thickness of 0.635mm and the SiN layer 31 -- in the thickness of 60nm and the TbFeCo perpendicular magnetization layer 14, the thickness of 20nm and the SiN layer 32 set [the thickness of 5nm and the FeSiAl soft-magnetism ground layer 12 / the thickness of 200nm and an interlayer 13] thickness of 5nm and the C protective layer 15 to 5nm
[0051] SNR in 200kFCI(s) to the interlayer 13 of various kinds was as follows. In addition, record reproducing characteristics presupposed that it is the same as the case of the 2nd example of the above.
Interlayer 13 SNR (Spp/Nrms)
SiN 24.1 Y-SiO2 23.9C Since change was hardly looked at by SNR even if it changed 24.3, thus interlayer's 13 kind, it has checked that it was effective in a raise in SNR like the case of the above 1st - the 4th example to make thickness of the perpendicular magnetization layer 14 small relatively to an interlayer's 13 thickness.
[0052] Next, the 6th example of the vertical-magnetic-recording medium which becomes this invention is explained. The structure of the 6th example of a vertical-magnetic-recording medium is the same as the case of the 2nd example of the above shown in drawing 7 .
[0053] In this example, composition of the perpendicular magnetization layer 14 was changed and the over-writing (O/W) property at the time of changing the size of holding power was investigated. 60kFCI(s) at the time of recording the signal of 360kFCI on the signal of 60kFCI erased over-writing, and it investigated the remainder. The record reproduction experiment system used the same thing as the 2nd example of the above. moreover, the thickness of a glass substrate 11 -- the thickness of 0.635mm and the SiN layer 31 -- in the thickness of 60nm and the TbFeCo perpendicular magnetization layer 14, the thickness of 20nm and the SiN layer 32 set [the thickness of 5nm and the FeSiAl soft-magnetism ground layer 12 / the thickness of 200nm and the SiN interlayer 13] thickness of 5nm and the C protective layer 15 to 5nm In addition, since coercive force and the value of saturation magnetization may change with membrane formation conditions even if it is the same composition, TbFeCo also measured SNR in 200kFCI(s) as the change and reference of an over-writing (O/W) property to coercive force.
TbFeCo coercive force (kA/m) O/W (dB) SNR (Spp/Nrms)
166 -50 24.1 300 -48 24.3 355 -48 24.2 480 -40 24.8 624 -35 24.9 850 Even if -2022.1, thus an interlayer's 13 thickness are greatly set up compared with the thickness of 60nm and the perpendicular magnetization layer 14 The coercive force Hc of the perpendicular magnetization layer 14 could check that about 600 kA/m could fully record, and the fall of the record capacity by increase of an interlayer's 13 thickness has also checked not becoming a problem practical.
[0054] Next, one example of magnetic storage which becomes this invention is explained. The vertical-magnetic-recording medium which becomes this invention is used for this example of magnetic storage.
[0055] Drawing 12 is the plan showing the example of magnetic storage. As shown in this drawing, the actuator 107 to which the horizontal displacement of the carriage arm 106 and the carriage arm 106 which fix the surfacing head slider 104 which counters the magnetic disk 103 with which the axis of rotation 102 and the axis of rotation 102 are equipped, and a magnetic disk 103, the arm shaft 105, and the surfacing head slider 104 at a nose of cam, and move a magnetic-disk 103 top to the housing 101 of magnetic storage 100 horizontally centering on the arm shaft 105 is driven and carried out is held. When performing informational record or informational reproduction to a magnetic disk 103, the carriage arm 106 drives with the actuator 107 which consisted of magnetic circuits, and it is positioned on the truck of the request on the magnetic disk 103 which the surfacing head slider 104 rotates. The magnetic head 200 is formed at the nose of cam of the surfacing head slider 104. In addition, this magnetic head 200 shows the state where drawing 12 removed for convenience covering formed in the upper part of housing 101.
[0056] A magnetic disk 103 may have which composition of the 1st - the 6th example of the above-mentioned

vertical-magnetic-recording medium.
[0057] Next, the relation between the thickness of the interlayer 13 of a magnetic disk 103 and the magnetic spacing from the surfacing side of the shielded type GMR head which constitutes the magnetic head 200 to magnetic-disk 103 front face is explained with drawing 13 and drawing 14 . Drawing 13 and drawing 14 show only the specific layer of a vertical-magnetic-recording medium for convenience.
[0058] Drawing 13 is drawing explaining a relation with the vertical-magnetic-recording medium shown in a shielded type GMR head and drawing 1 . That is, drawing 13 shows the case where a magnetic disk 103 has the structure of drawing 1 . The same sign is given to the same portion as drawing 1 among drawing 13 , and the explanation is omitted.
[0059] In the case of drawing 13 , in the combination of the vertical-magnetic-recording medium shown in GMR head200A and drawing 1 , the shield gap 300 is 50-200nm, and the magnetic spacing 301 to GMR head 200A and a medium front face (perpendicular magnetization layer 4) is 20-80nm. In this case, since the perpendicular magnetization layer 4 approaches and exists in the soft-magnetism ground layer 3, the magnetic flux generated from the magnetization in the perpendicular magnetization layer 4 flows to the soft-magnetism ground layer 2 as it is. For this reason, the soft-magnetism ground layer 2 will be locally joined by the strong perpendicular direction magnetic field. Therefore, by soft magnetic materials, although the magnetization of the soft-magnetism ground layer 3 which essentially has a magnetic anisotropy in a field must also rotate locally, since strong switched connection is working, a local magnetization change becomes unstable in energy. For this reason, steep magnetization transition formation of the perpendicular magnetization layer 4 is checked, or the magnetic domain of the soft-magnetism ground layer 3 is disturbed. The former causes attenuation of the regenerative signal of high-density record, and the latter causes a medium noise.
[0060] Drawing 14 is drawing explaining a relation with the 1st example of the vertical-magnetic-recording medium shown in a shielded type GMR head and drawing 2 . That is, drawing 14 shows the case where a magnetic disk 103 has the structure of drawing 2 . The same sign is given to the same portion as drawing 2 among drawing 14 , and the explanation is omitted.
[0061] In the case of drawing 14 , the perpendicular magnetization layer 14 is located in the side near [layer / soft-magnetism ground / 12] GMR head 200A. Therefore, as shown in this drawing, the magnetic flux generated from the magnetization in the perpendicular magnetization layer 14 is not concentrated on the part of the soft-magnetism ground layer 12. Consequently, change of magnetization of the soft-magnetism ground layer 12 becomes loose, and increase of the regenerative signal of high-density record and the reduction of a medium noise of it are attained.
[0062] Drawing 15 is drawing showing the measurement result of the thickness dependency of the SiN interlayer 13 of signal level in case the magnetic spacing 301 to GMR head 200A and the medium front face (perpendicular magnetization layer 14) which are shown in drawing 14 is 30nm, and noise level in this example. A vertical axis shows carrier level (dBm) and noise level (dBm) among this drawing, and a horizontal axis shows an interlayer's 13 thickness (nm). Moreover, in O mark, a carrier level example and - mark show noise level. The measurement result shown in this drawing was searched for by changing the SiN interlayer's 13 thickness and measuring the signal (dBm) of 400kFCI by the spectrum analyzer. When an interlayer's 13 thickness was set to 40nm or more more greatly than the magnetic spacing 301 so that it might understand also from this drawing, it has checked that a carrier pair noise ratio (CNR) improved.
[0063] Thus, according to this example, without reducing record sensitivity taking advantage of the feature of a reproduction sensitivity distribution of a shielded type GMR head, reduction of the medium noise resulting from a soft-magnetism ground layer can be aimed at, and the vertical magnetic recording of outstanding SNR can be performed.
[0064] As mentioned above, although the example explained this invention, this invention is not limited to the above-mentioned example, and it cannot be overemphasized that deformation and improvement various by within the limits of this invention are possible.
[0065]
[Effect of the Invention] According to this invention, the vertical-magnetic-recording medium and magnetic storage which can reduce the medium noise which originates in a soft-magnetism ground layer, without reducing record sensitivity are realizable.

[Translation done.]